A NEW DINOSAUR.

From the Queensland Cretaceous.

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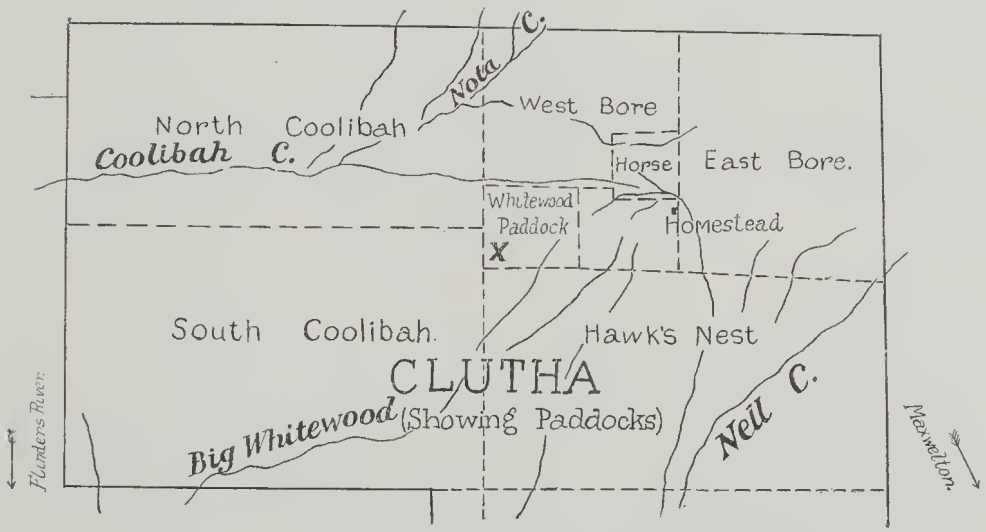
(Plates XV–XVII, Text-figures 1–3.)

INTRODUCTION.—When visiting "Clutha" Station, Maxwelton, North-west Queensland, in August last, Dr. M. J. McKillop, of Brisbane, was interested in some large fossil remains of vertebræ which were shown to him by his brother, Mr. H. J. McKillop, the manager. In response to my request, through Dr. McKillop, these specimens were carefully packed and forwarded to the Queensland Museum, where they were received on 9th January, 1933.

LOCALITY.—"Clutha" is north of the Flinders River, and the homestead is 34 miles from Maxwelton, on the Great Northern Railway, 337 miles west of Townsville, North Queensland.



Text-figure 1.—Part of Clutha Station showing Whitewood Paddock. Site of Fossils marked X.

Del. T. C. Marshall, from Qld. Four Mile Maps, Sheet 82 (Enlarged).

Mr. H. J. McKillop informs me that the fossils were first discovered by the overseer, Mr. H. B. Wade, who noted them on the surface partly exposed in black soil on open down country, "in what is known as Whitewood Paddock, at a spot approximately three miles west of the homestead and about

two miles from Coolibah Creek. There are no public roads on 'Clutha,' but there are many private tracks on the run, and one of these passes within a few hundred yards of the site of the discovery. The area of the paddock is 1,200 acres." (Text-figure 1.)

As the locality is within a district that has provided many fossils representing Lower Cretaceous marine reptiles, it was anticipated that the large vertebræ would be those of *Kronosaurus queenslandicus*,[1] the largest known species. To my surprise and intense interest, however, when the "Clutha" fossils were examined it was obvious that they represented a new giant Dinosaur, the first to be obtained from the Lower Cretaceous deposits of Queensland. The stratigraphical problems associated with this discovery are discussed later.

AUSTROSAURUS* McKILLOPI, genus and species new.

Dorsal vertebræ markedly opisthocœlous; centra with thin cortical walls, much enlarged at the enarthrodial articulations; intramural region a complex of small cavities; pleurocœles prominent, with external and internal divisions. Neural arch with deep recess between the prezygapophysial lamina and the infradiapophysial buttress.

This tentative generic diagnosis will obviously need to be supplemented when more complete material is forthcoming. The proportions and some of the characteristics of the vertebræ, however, appear significant, and it is anticipated that this Australian Cretaceous Dinosaur will prove, when better known, as distinctive as most of the giant Sauropoda found in similar deposits elsewhere.

Material.—This consists of three massive blocks, each containing incomplete paired vertebræ cemented together at the enarthrodial articulations of the centra. Owing to the extreme development of the intramural cavities, these vertebræ, although so massive, are very fragile. With the exception of the articulating surface of the "cups" and "balls," the peripheral walls are surprisingly thin. The layers of bone have now been strengthened by repeated soakings in shellac solution. The matrix (described elsewhere) is much more durable than the actual fossil, and the partial clearing of the bones necessitated much patient work. The specimens were evidently weathered out of the original formation long before their discovery, and they were found lying in

[1] Longman, H. A., Mem. Qld. Mus., VIII, Pt. 1, 1924, X pt. 1, 1930, and X pt. 2, 1932.

* Following numerous precedents, the prefix "Austro" has been used for its present geographical significance, and this is also in consonance with the nomenclature of many modern genera of Dinosaurs, distinctively named from other parts of the world.

black soil, some rootlets actually being present in the interstices. Owing to the effects of prolonged abrasion and weathering, large portions of the original contours have been lost.

For convenience in description the specimens have been designated A, B, and C. (Reg. No. F2316.)

Description.—Specimen A consists of the major portion of one centrum, with the lower part of the neural arch, and the fractured "cup" of the contiguous unit, which has fragments of its arch in the matrix above. In the more complete vertebra, the posterior part of the centrum has been shorn away, and the cross section of fracture shows within the thin walls a coarse mosaic of irregular cancelli enclosed by thin bony plates. These intersecting laminæ form a labyrinth throughout the exposed transverse section of the centrum, but are most prominent where supporting the cortical walls. The cancelli are wholly or partly infilled with a crystalline matrix of carbonate of lime (described elsewhere).

The lateral walls of the right side of the centrum have disappeared, but the anterior part of the left lateral surface is preserved, with an almost complete pleurocœle. This area has been largely freed from the matrix and exhibits important characteristics (Plate XV.). Of the actual walls of the inferior surface of the centrum only a small portion is preserved, but the general proportions are apparent. When viewed from below, it is seen that the body of the centrum is constricted and the lateral walls curve outwards anteriorly to the much larger rim of the "ball." This constricted portion of the centrum, with its associated lateral cavities, is evidently fragile in comparison with the articular areas, for all of the specimens are fractured in this region.

The dimensions of Specimen A are as follows:—Maximum length $10\frac{1}{2}$ inches (267 mm.); height $16\frac{1}{4}$ inches (413 mm.); transverse diameter $10\frac{1}{8}$ inches (257 mm.).

Pleurocœle.—This is situated in the upper portion of the centrum and is well shown in Plate XV. This large lateral cavity is divided into an external and an internal portion. The former is a large horizontal oval recess, from which the matrix has been cleared, and at the bottom is a much smaller oval fenestra, the internal pleurocœle, which extends further into the centrum. The external recess is about 42 mm. in depth; its antero-posterior diameter is approximately 90 mm., and its vertical height is 60 mm. The lower wall of this cavity forms an almost horizontal shelf, but, from the inner surface, the upper and anterior walls curve gradually outwards to the plane of the lateral surface. The matrix has been almost entirely cleared from the internal pleurocœle, the diameters of which are approximately 50 mm. by 30 mm. This inner recess is divided into two portions by a thin vertically-placed bar of bone, situated at the anterior third.

On the right side the walls of the centrum have entirely disappeared. The pleurocœle is shown in section, and was originally infilled with matrix which was surrounded with very thin peripheral walls. The typically marine matrix has now been removed on each side, so far as it is safe to do so. The two pleurocœles are not confluent, but the matrix terminates against the laminar complex, which forms so distinctive a feature of the centrum, within about 20 mm. from the median line. No trace of a median vertical partition can be seen in the fractured surface across the centrum, and the laminar complex evidently takes the place of this structure.

Neural Arch.—This region is very incomplete, and the right side has largely disappeared. The full height is not preserved, but the fractured surface above exhibits a complex of abraded and distorted elements. It is obvious, however, that the laminæ and brackets were very extensive and were lightly framed.

The preserved portions present significant similarities in this region with those shown in the well-known figure of the vertebra of "*Ornithopsis*" *hulkei*, first described and figured by J. W. Hulke in 1880.[1]

Owing to the presence of an almost complete fracture in the fossil, it has been possible to remove the major portion of the neural arch from its basal part. The exposed contours give some interesting details of the internal structure. From the upper margin of the centrum, near the anterior rim, a curved plate, somewhat "saddle-shaped," is produced anteriorly and outwardly. The basal portion of its anterior surface, when viewed from the lateral aspect, arises almost vertically, but the upper portion, as may be seen from impressions in the matrix, expands outwardly and anteriorly, evidently supporting prezygapophyses which projected over the border of the contiguous vertebra (Plate XVI.). This infraprezygapophysial lamina (to use Osborn and Mook's revised term[2]), is very incomplete, but it appears to have been much more extensive in this vertebra than in other related Dinosaurs, judging from impressions in the matrix. Its median portion is incomplete. The base of a similar lamina is preserved on the right side, and this meets the base of the left lamina above the neural canal. When viewed from above, the fractured section shows that the median extension of each lamina curves posteriorly to meet its fellow, forming a wide recess above the neural canal. The hypantrum-hyposphene articulation is not preserved, but was evidently present above the fractured section.

A large recessed area lies between this anterior lamina and the infra-diapophysial buttress. This recess is relatively very large and attains a depth of at least 60 mm. (Text-figure 3). Only the basal part of the median portion

[1] Hulke, J. W., Quart. Journ. Geol. Soc., Vol. 36, pp. 32-34, plate iv.

[2] Osborn and Mook, Mem. Amer. Mus. Nat. Hist, n. s. III., 1921.

Austrosaurus mckillopi. Lateral view of Specimen A—incomplete dorsal vertebræ (Holotype).

(*Approximately one-third natural size.*)

Face page 134.

Photo., W. J. Sanderson.

of the pedicle of the arch is preserved, as may be seen in Plate XV. Unfortunately the postzygapophysial region and the whole of the platform supporting the transverse process are missing. Judging from fragments exposed in the matrix over the remnant of the contiguous vertebra, however, the region of the diapophyses was situated high in the neural arch,—at least as high above the centrum as the vertical diameter of the centrum.

Rib.—A fragment of a rib is preserved in the matrix between the two vertebræ on the left side (Plate XV.). In section this is oval, with one side flattened, the diameters being 90 mm. by 40 mm.

Neural Canal.—The matrix in the site of the neural canal is well preserved in all three specimens, and is transversely oval in section. The average transverse diameter is 50 mm., and the vertical height is 35 mm. The cylinders of matrix are partly exposed above in Specimens B (Plate XVII.) and C.

Immediately above the region of the canal in A is an arch of bone showing an elongated isosceles triangle in section, as seen in the matrix, but the plates are very thin as preserved. This structure is seen in the anterior and posterior sections now exposed in Specimen A, and it is also noticeable in the section of Specimen B. It appears to be a distinctive feature of the intramural laminæ of the neural arch (Plates XVI. and XVII.).

Specimen B shows subequal portions of two incomplete vertebræ. The anterior element mainly consists of the expanded rim of the "cup," which is closely adpressed to the "ball" of the adjoining unit. The preserved portion of the body of the centrum is almost entirely intramural and consists of a mosaic of large cancelli. The matrix of part of the neural canal is present.

The associated vertebral fragment consists of an incomplete centrum containing a pleurocœle on each side. On its posterior surface it exhibits the inner portion of the deep cup. So much of the rim is missing, however, that the maximum length of the complete vertebra cannot be precisely estimated. The concavity is now covered with a thin tessellated layer, which evidently represents the original cartilage now changed to crystals of carbonate of lime (Plate XVII.). The preserved portion is 180 mm. in transverse diameter, with a vertical height of 135 mm.

The anterior base only of the neural arch is preserved. As exposed in the matrix, the right and left anterior laminæ exhibit "saddle-shaped" contours resembling those described from the more complete elements in specimen A. The neural canal matrix, consisting of a vertically compressed oval cylinder (54 mm. x 40 mm. in section) is also preserved. Above this an elongated isosceles triangle of matrix is enclosed within thin plates of bone, as in Specimen A.

The pleurocœles in this centrum are less elongated than those in Specimen A, and are infundibulate. They are more obliquely placed in the

upper part of the centrum. The great differences in the size of the pleurocœles shows that B was not consecutive with A in the vertebral series, but it is considered that they were not widely separated.

On the lower surface the peripheral walls are incomplete. In section the contours are broadly convex, but medially there is a shallow depression running longitudinally along the centrum.

The dimensions of Specimen B are :—Maximum length $11\frac{3}{4}$ inches (299 mm.) ; transverse diameter $12\frac{1}{4}$ inches (306 mm.) ; height $12\frac{1}{8}$ inches (303 mm.).

Judging from the proportions of the parts preserved, this vertebra was distinctly shorter than those represented in Specimen A, but was much more massive transversely.

Specimen C consists of the massive rim of a "cup" shorn from a centrum and cemented with matrix to the associated "ball." On the lower surface, portions of the external walls are preserved, although greatly crushed, but otherwise the cortical bone has entirely disappeared. On the right side an oval mass of matrix (60 mm. x 25 mm.) is seen obliquely situated deep in the body of the matrix, denoting the inner part of a pleurocœle. Near the border of the "cup," midway between the inferior and superior margins of the centrum, an additional oval mass of matrix is seen on one side. This matrix, which is a small oval vertically placed, apparently represents an additional pleurocœle, much smaller (diameters approximately 40 x 20 mm.) and quite separate from the larger lateral cavity.

Specimen C has been subjected to great vertical pressure, and the cylinder of matrix representing the neural canal has been crushed down into the cancellous tissue of the centrum. The expanded rim, although cracked, has not suffered so much as the median portions, but the transverse diameter is probably somewhat enlarged by intense pressure during fossilisation.

Specimen C is relatively massive in comparison with the other fragments. Its transverse diameter is no less than $13\frac{1}{4}$ inches (336 mm.), The maximum length is $11\frac{3}{4}$ inches (299 mm.—and the height of the specimen as preserved is 9 inches (229 mm.).

The predominance of the transverse diameter over the vertical diameter—quite apart from the distortion owing to pressure—suggests that the two vertebræ represented came from near the sacral region.

Although very incomplete, these specimens definitely show that this Queensland Cretaceous Dinosaur exhibits in its dorsal series of vertebræ the variability which is characteristic of most of the Sauropoda.

Austrosaurus mckillopi. Posterior view of Specimen A, showing transverse fracture of centrum and intramural complex of cavities.

(*Approximately one-third natural size.*)

Face page 136.

Photo., W. J. Sanderson.

Affinities.—Matley (1931, p. 281),[1] in commenting on the connexion in Mesozoic times of South America with south-eastern Asia by way of Antarctis, the Australian region and the Sunda Archipelago, as discussed by von Huene, says that it is "really remarkable that all the three Cretaceous sauropod genera of India—*Titanosaurus*, *Antarctosaurus*, and *Laplatasaurus*—should be found so far away as Patagonia." &c. Notwithstanding the wide range of these and other sauropodous genera, it is difficult to place this Queensland Cretaceous Dinosaur with any well-known types, in so far as comparisons can be made with our material. *Austrosaurus* does not closely resemble any of the species described by von Huene[2] in his comprehensive work "Los Saurisquios y Ornitisquios del Cretaceo Argentino," and it evidently does not belong to the Family Titanosauridæ.

Austrosaurus mckillopi appears to be a more specialized Dinosaur than the Queensland Jurassic Sauropod *Rhætosaurus brownei*, described by the writer.[3] In *Austrosaurus* the centra of the dorsal vertebræ attain a maximum of specialization in the intramural complex of laminæ enclosing irregular cavities, supplementing the actual recesses of the pleurocœles. It is not clear whether the pleurocœles are actually connected with the complex of small internal cavities. Judging from the condition of the matrix, however, they were not, and probably only the lateral recesses were actually pneumatic in life. Owen's view[4] that the inner recesses of such centra were filled with "chondrine," although opposed by Seeley and Hulke,[5] may well be true.

Apparently there are two types of cavernous dorsal vertebræ in the Sauropodous Dinosaurs. In one type, the lateral cavities or pleurocœles extend into the intramural area and form an enlarged chamber, recessed behind the actual opening: there is no complex of small cavities and the additional required strength of the centrum is formed by thick portions of the peripheral walls and a median vertical partition.

This type of vertebra is illustrated by the transverse section of the trunk centrum of "*Ornithopsis*" figured by Hulke in 1879,[6] here reproduced (Text-figure 2). The section of a dorsal vertebra of Marsh's *Morosaurus lentus* (*Camarasaurus*, Cope) illustrates another development of this type,[7] and many other examples are known. Osborn and Mook record (*loc. cit.*, 1921, p. 306) that in *Camarasaurus* the pleurocœles "occupy most of the bodies of the centra."

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[1] Matley, C. A., Geol. Mag., Vol. LXVIII, 1931.

[2] Huene, F. von, Anales del Museo de La Plata, tomo III, serie 2, 1929.

[3] Longman, H. A., Mem. Qld. Mus., VIII, pt. 3, pp. 183-194, Plates XXIX-XXXIII; Mem. Qld. Mus., IX, pp. 1-18, Plates I-V; Australian Museum Mag., Vol. III, No. 3, pp. 97-102; Mem. Qld. Mus., IX, pt. 3, p. 249, Plate XXIX.

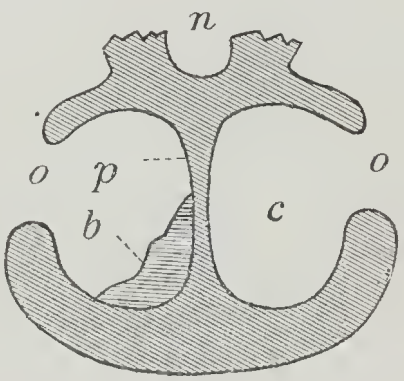
[4] Owen, R., Mon. Foss. Rept. Weald. & Purb., Supp. No. VI, 1874, p. 6.

[5] Owen, R., Quart. Journ. Geol. Soc., vol. 35, 1879, p. 762.

[6] Hulke, J. W., Quart. Journ. Geol. Soc., 1879, Vol. 35, p. 756.

[7] Marsh, O. C., The Dinosaurs of North America, 16th Ann. Rep. U. S. Geol. Sur., 1896, Plate XXXII, fig. 2a.

In the other type, the lateral cavity or pleurocœle forms a recess which is not expanded within the centrum; the peripheral walls may be surprisingly thin, and most of the intramural space is filled with a complex of small laminar cavities. These laminæ reinforce the thin peripheral walls, exhibiting an extraordinary combination of strength with relative lightness. The majority



Text-figure 2.—Transverse section of dorsal vertebra of *Ornithopsis* (after J. W. Hulke). *n.* Neural canal, *p.* partition, *b.* buttress, *c.* chamber, *o. o.* lateral openings to chambers.

of the small inner cavities appear to be more or less insulated, and there is no evidence of connecting passages between the lateral recess and this inner complex. This type of vertebræ is well illustrated in *Diplodocus carnegii*, as fully described by J. B. Hatcher (1901), who refers to the "remarkable degree of specialization, unsurpassed if not unequalled by other vertebrates in the general characters of its vertebral column in its adaptation of these mechanical principles which combine maximum strength with minimum weight (p. 12).[1]

It is very evident that the vertebræ of *Austrosaurus mckillopi* resemble those of *Diplodocus* in the special structure of the centrum. A transverse section of the centrum of Specimen A, shown in Text-figure 3, illustrates the proportions of the pleurocœles, taken at their maximum extent, and the intramural complex of cavities surrounding them. The recess behind the anterior lamina, above the centrum, is also indicated.

A longitudinal section of a vertebra of *Austrosaurus* would exhibit a somewhat similar structure, but more complex, to that figured by Owen in his "*Chondrosteosaurus*" from the Wealden deposits of the Isle of Wight.[2]

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[1] Hatcher, J. B., Mem. Carnegie Museum, Vol. 1, 1901, p. 12.

[2] Owen, R., Mon. Foss. Rept. Wealden & Purbeck, Pal. Soc. Supp. VII, 1876, Pl. V, fig. 2.

The type centrum of "*Bothriospondylus magnus*" as figured by Owen, which is also the type of Seeley's *Ornithopsis*, shows the same characteristics.[1] Seeley's and Owen's genera are now usually included in the synonymy of Mantell's

Text-figure 3.—Section of vertebra of *Austrosaurus mckillopi* taken at the maximum extent of the pleurocœles, showing also the recess in the neural arch. The complex of intramural cavities is shown somewhat diagrammatically. (One-half natural size.) *Del. M. J. McKillop.*

[1] Owen, R. (*loc. cit.*), part 2, Plate IX, fig. 1.

Pelorosaurus,[1] but if the centra figured by Hulke, previously mentioned, are congeneric, there is an extraordinary range of variation in structure—even for a sauropodous Dinosaur—in this genus.

A. Smith Woodward, records: "In *Ornithopsis* the centrum of each vertebra is chambered throughout, and the thin partitions between the small cavities consist of hard dense bone.[2]

In his paper, "Zur Systematik und Biologie der Sauropoden" (1930)[3] Baron Franz Nopesa touches on the differential development of pleurocœles, but he does not deal with the significance of an intramural complex of small cavities, and I can find no special references in Baron Huene's papers.

In Zittel's Text-book of Palæontology (Eng. Ed. 1902) only two families of Sauropoda, the Camarasauridæ and the Diplodocidæ, are recognised, whereas Marsh had previously recorded six. Four families are listed in "The Osteology of the Reptiles" by S. W. Williston (edited by W. K. Gregory, 1925), with a long list of genera *incertæ sedis*. Huene, however, lists six families in 1927 ("Short Review of the Present Knowledge of the Sauropoda," These Memoirs, Vol. IX. pt. 1, 1927). He divides the Cetiosauridæ into two sub-families: "Cardiodontidæ and Brachiosauridæ," and points out that the vertebræ of the latter are more cavernous than those of the former, although neither are so cavernous as in the families Morosauridæ and Diplodocidæ. It is doubtful whether the multiplication of families will tend to elucidate the phylogeny of this group. At present we have specialized genera such as *Diplodocus* in the Upper Jurassic with no known descendants in the Cretaceous, whilst, as R. S. Lull and F. Nopesa[4] have pointed out, the comparatively simple type of *Titanosaurus* occurs in the Upper Cretaceous.

As von Huene states, the natural classification of the Sauropoda is no yet clear. Doubtless our knowledge of their phylogeny will increase with new and more complete material. Where specimens are fragmentary the allocation of certain genera to families depends on the significance attached to certain features. As R. S. Lull points out, *Barosaurus* has several features in common with *Diplodocus* (including the two-branched characteristics of the chevrons, once thought distinctive), yet these are placed in distinct families.[5]

Notwithstanding the striking similarity between the intramural complex of the centra in *Austrosaurus* and *Diplodocus*, this Queensland Cretaceous

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[1] Mantell, G. A., Phil. Trans. Roy. Soc., 1850, p. 379.

[2] Woodward, A. Smith, P.Z.S., 1905, p. 232.

[3] Nopcsa, F., Palæobiologica, iii., Band, 1930.

[4] Nopcsa, F., Quart. Journ. Geol. Soc., Vol. LXXIX, 1923, p. 107.

[5] Lull, R. S., Mem. Connect. Acad. Vol. VI., 1919, p. 40.